



Introduction to High Performance Laboratories

**Victor A. Neuman, PE,
Tek-Air Systems Inc.**

Challenges For Today's Labs

*Lab Planning
Overview*

Hoods & Casework

*Exhaust
Stacks*





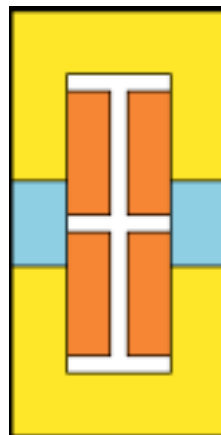
What Lab Users Want - Survey Results

Flexibility/adaptability/convertibility	56%
Space efficiency & synergy	40%
First cost/operating costs	32%
Working environment/natural light	20%
Large, Open Labs	10%
Greener Labs, less chemicals	
Instruments & data, less piped services	

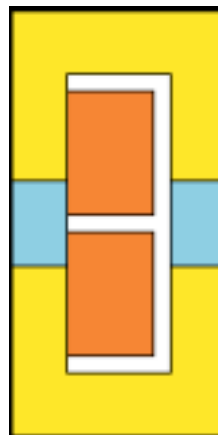
Laboratory Concepts



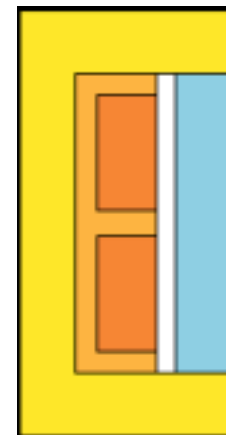
Race Track
60-65%



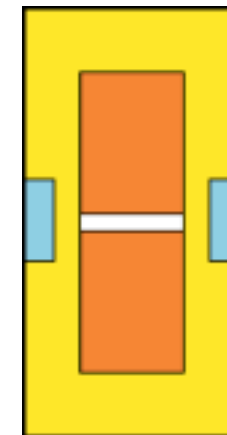
Center Corr.
65-70%



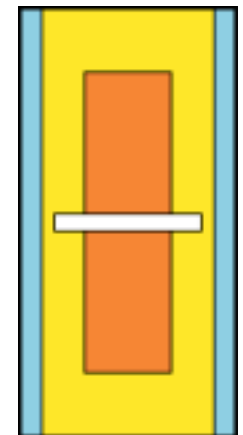
Ghost Corr.
65-70%



Linear Equip.
70-75%



Clustered Office
75-80%



Integrated
75-80%



Lab



Office



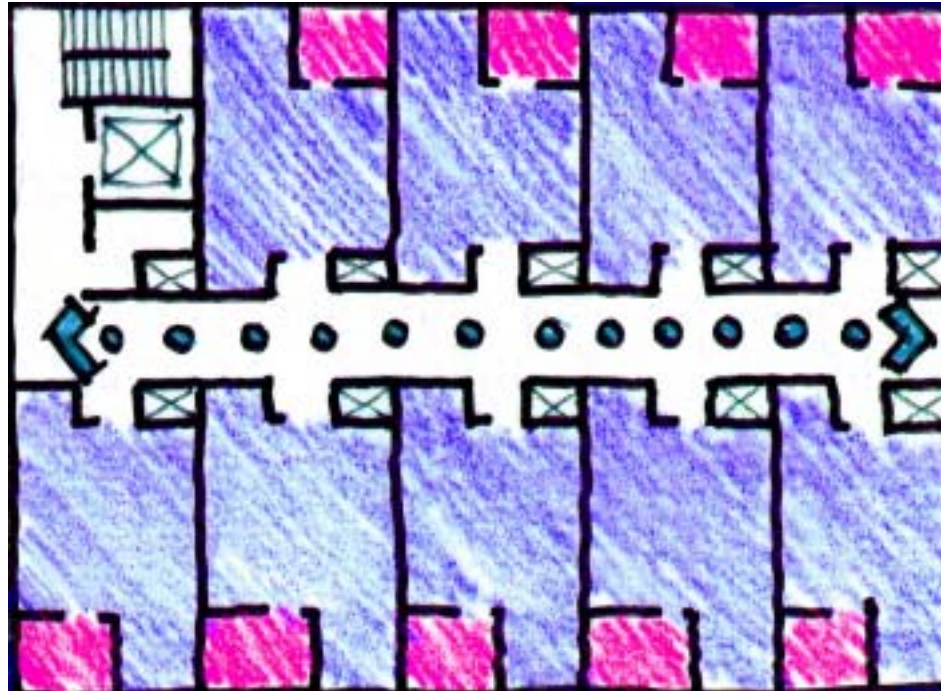
Lab Support



Linear Equipment Room

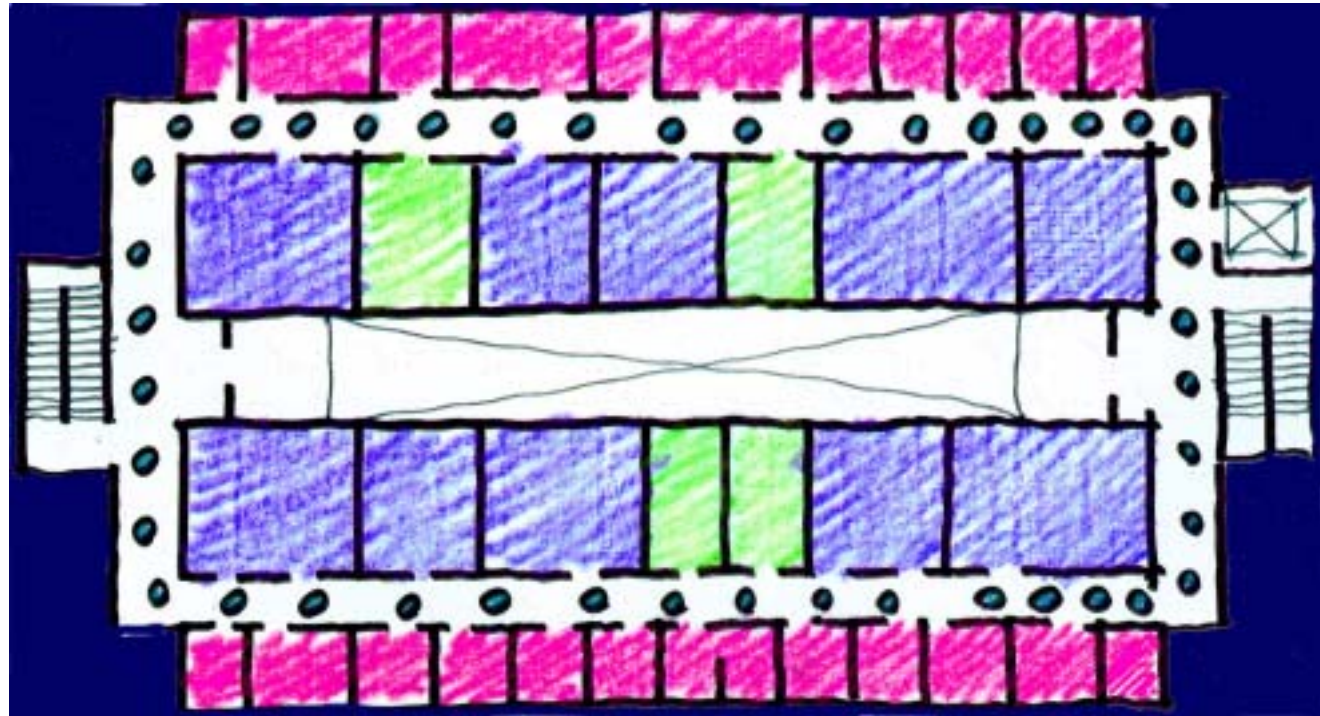
Graphics courtesy of
GPR Planners/JFI

1930-1950's



Linear

1960's



Service corridor

Salk Institute

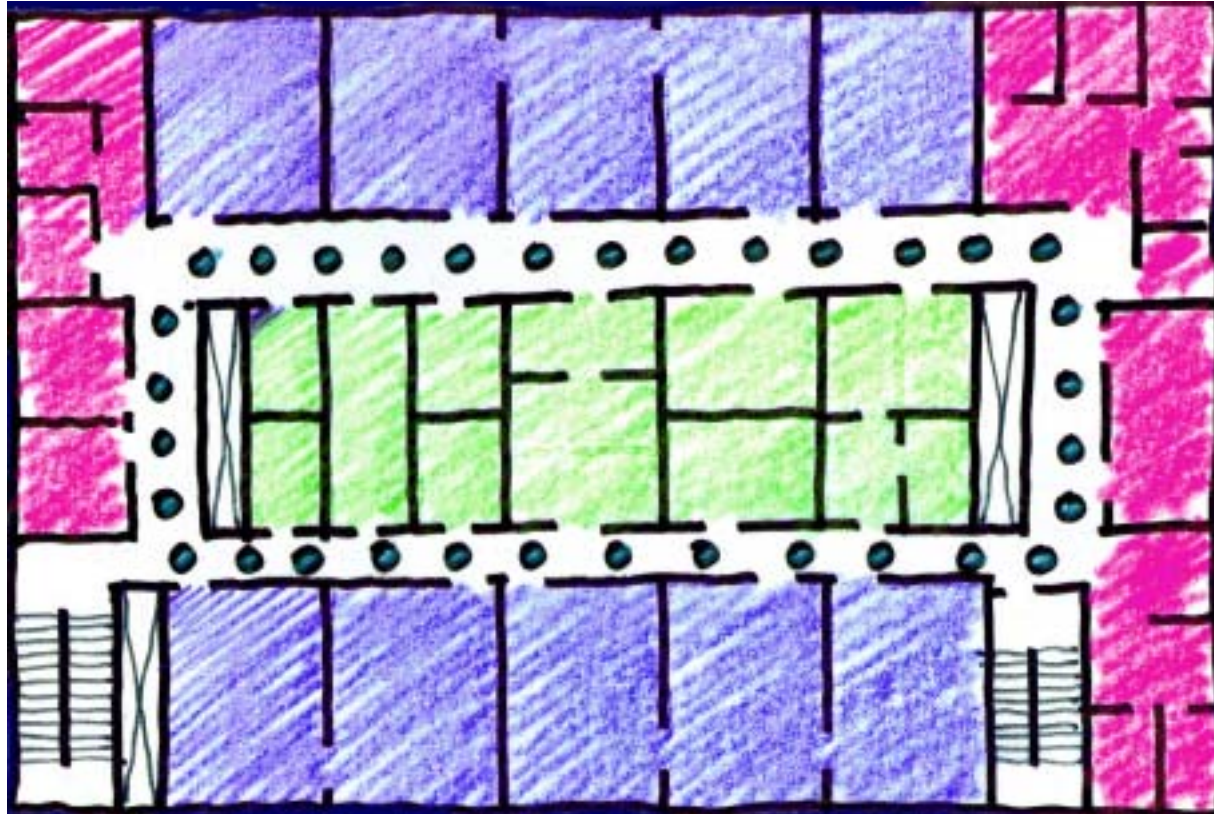
La Jolla, CA



■ 412,000
GSF

■ 1965

1970's

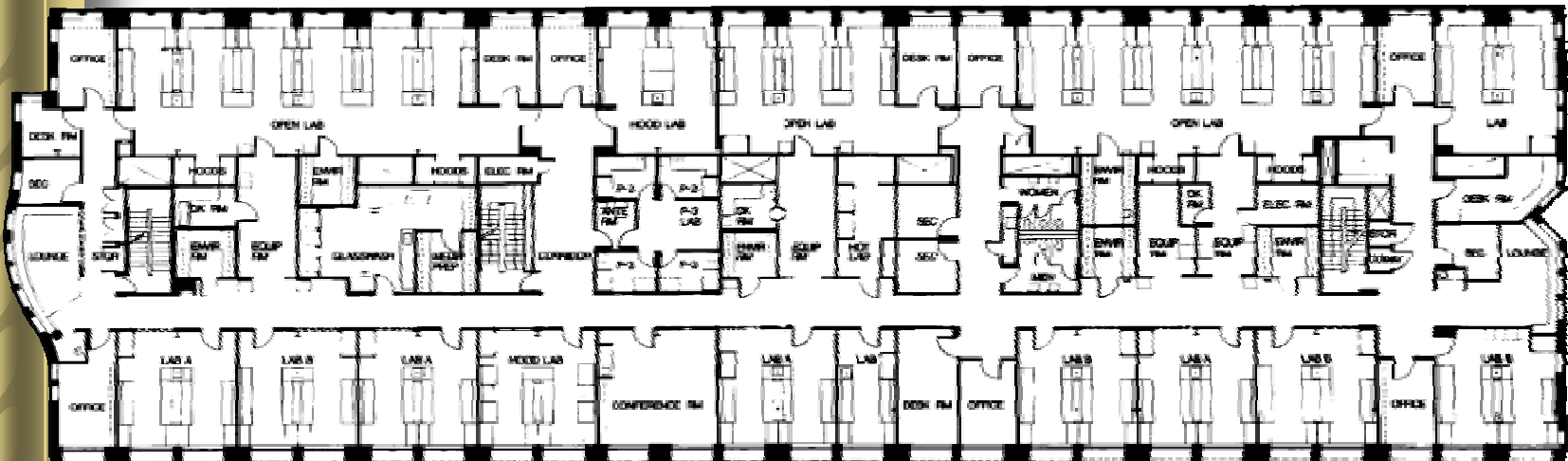


Racetrack

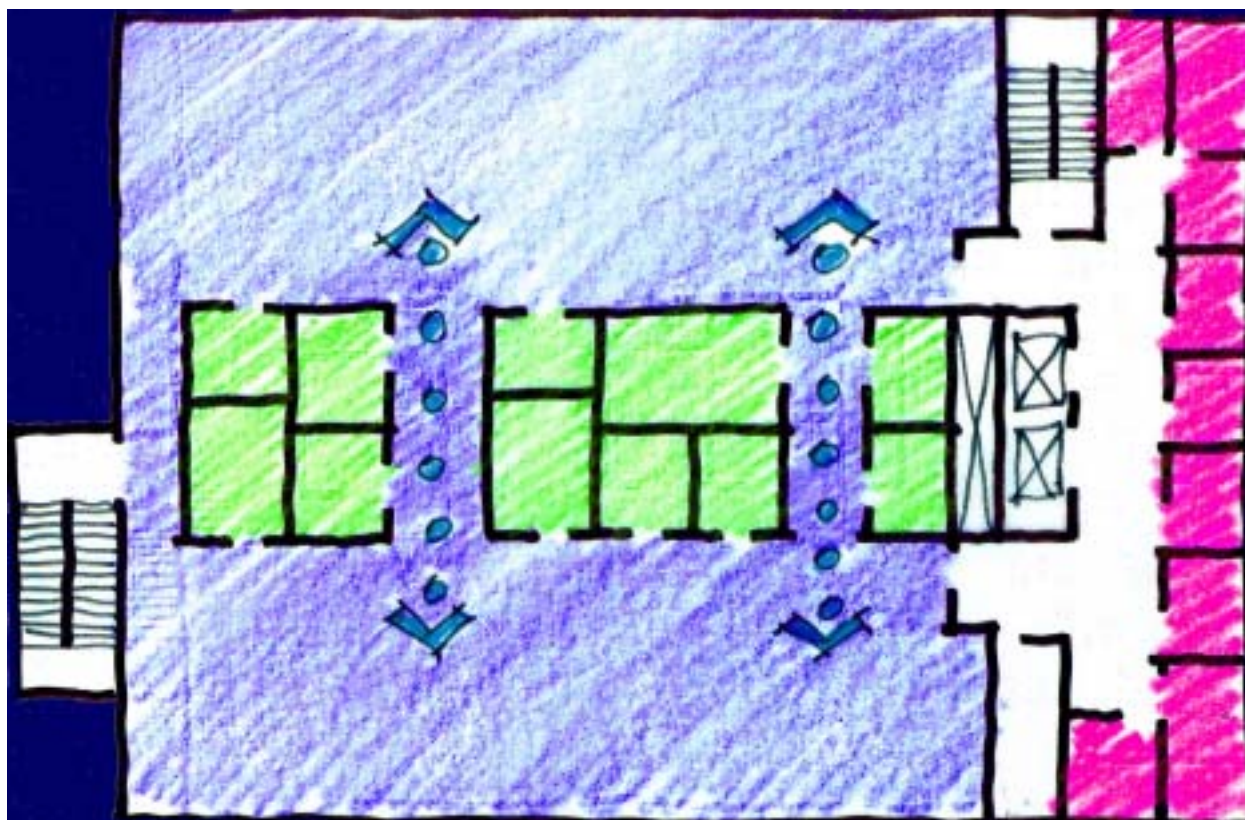
Princeton University

■ 178,250
GSF

■ 1986

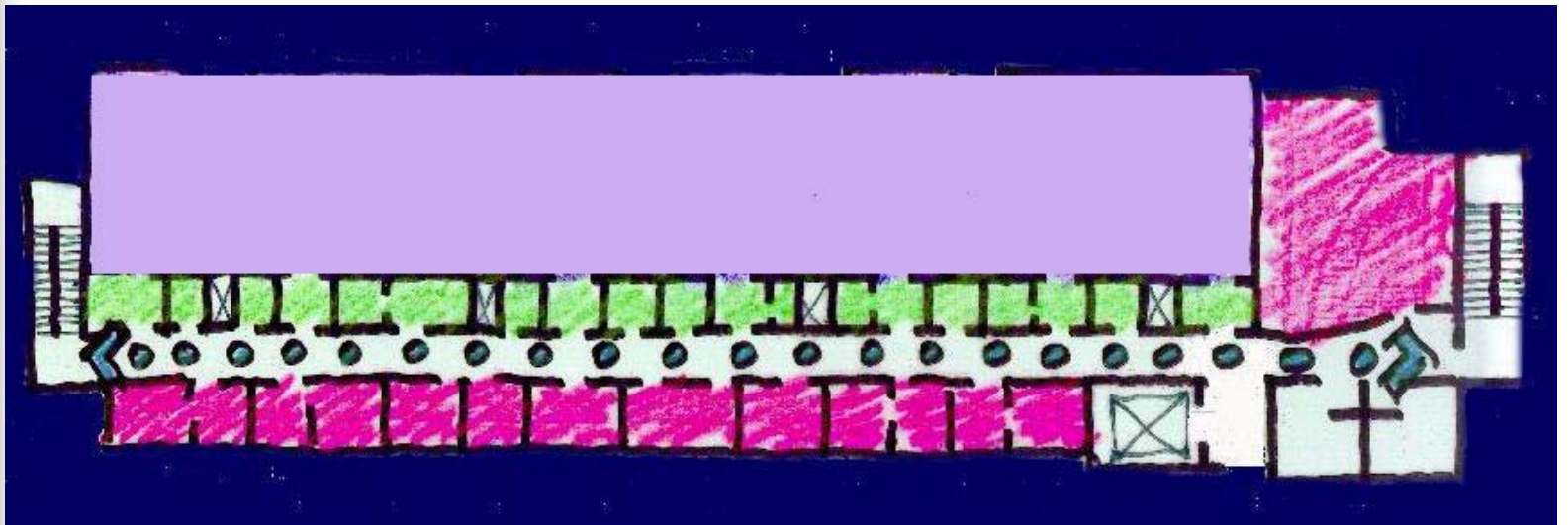


1980's



Suite

1990's



Lab block

UCLA Medical School



■ 130,000 GSF
/ 78,000 NSF

■ Efficiency:
60%

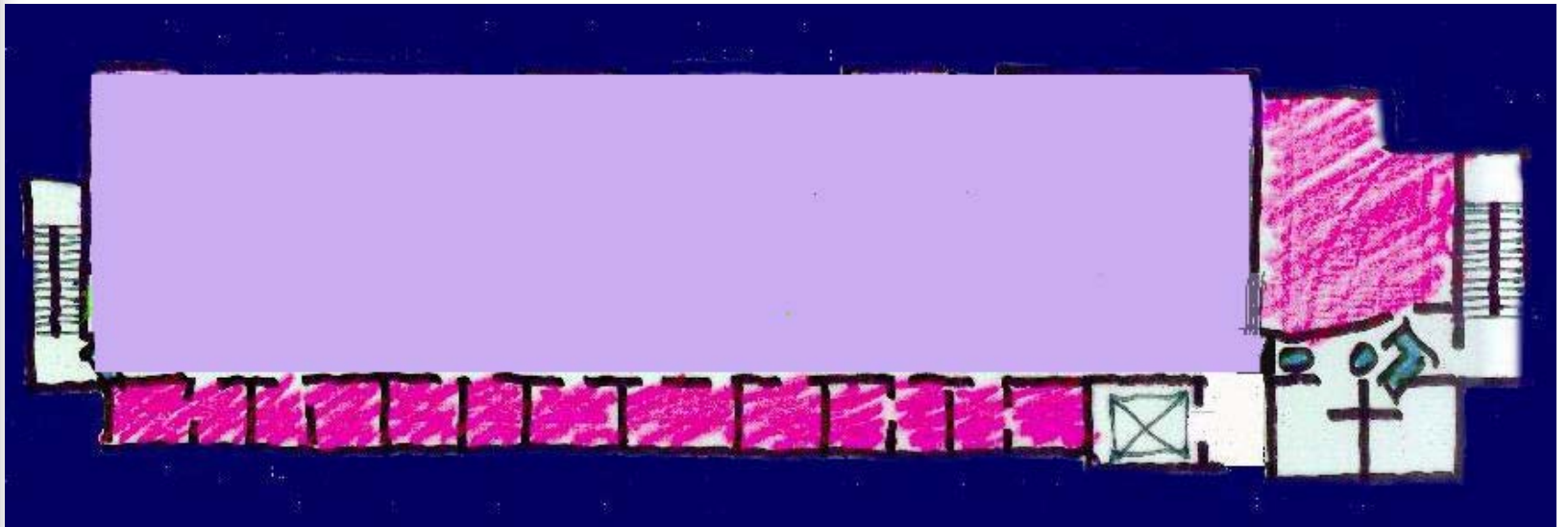
■ 2000

■ \$50 Million

University of Philadelphia, PA



2000-2005



Integrated



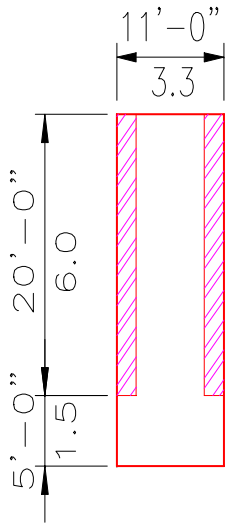
LABORATORY UNIT

- A code designation for an enclosed fire rated space
- Local or regional codes may limit the # of units allowed in a building
- It may include:
 - Laboratories & Support Rooms
 - Corridors & Lavatories & Storage
 - Offices & Conference ...
- Amount of chemicals stored determines B or H occupancy

LAB MODULE

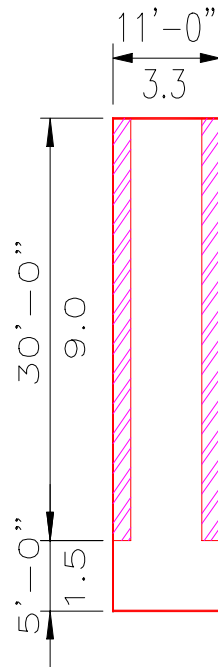
- A planning tool
- The smallest unit of measure used to define all spaces in a building
- The dimension of the module should be specifically defined for each project:
- Examples: **11' x 28'**
10'4" x 30'
12'x24'

MODULE EFFICIENCY STUDY



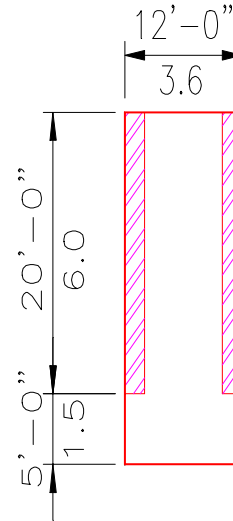
$$= 40 \text{ LNFT}/275 \text{ N.S.F.}$$

$$= 6.875/\text{FT}^2$$



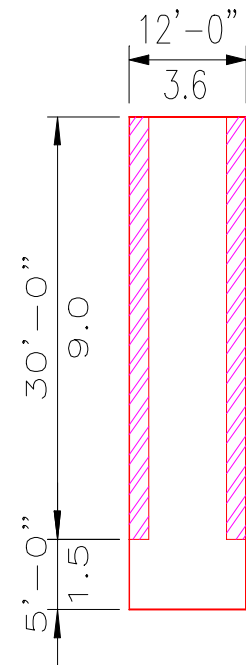
$$= 60 \text{ LNFT}/385 \text{ N.S.F.}$$

$$= 6.42/\text{FT}^2$$



$$= 40 \text{ LNFT}/300 \text{ N.S.F.}$$

$$= 7.5/\text{FT}^2$$



$$= 60 \text{ LNFT}/420 \text{ N.S.F.}$$

$$= 7.0/\text{FT}^2$$



Think Modular

- **Modular spaces are easily adaptable.**
- **Certain combinations of room sizes are allowable.**
- **Structural grid and MEP follows module.**
- **MEP serves module in a generic way.
Ex: One 6' hood per module.**



ARCHITECTURAL/ STRUCTURAL

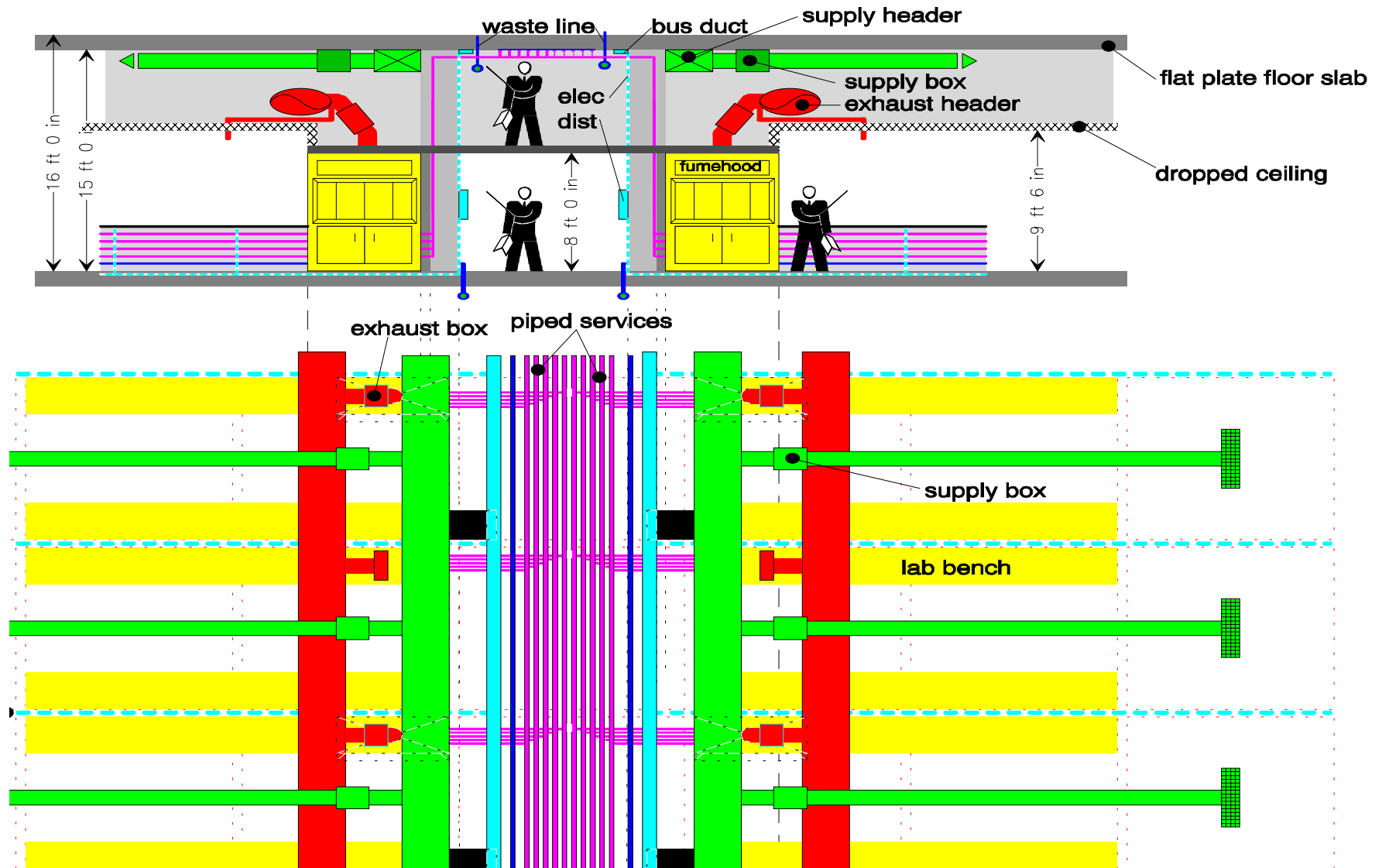
- **PLANNING
MODULE
DIMENSIONS**
- **CEILING HT.**
- **FLR-FLR HT.**
- **FLOOR LOADING**
- **STRUCTURAL
GRID**
- **CLEARANCES**
- **ADA REQUIREMENTS**
- **NOISE**
- **ARCHITECTURAL
FINISHES**
- **NATURAL LIGHT**
- **ARCHITECTURAL
DETAILS**
- **PERSONNEL ACCESS**



HVAC ISSUES

- **SPACE
TEMPERATURE
AND HUMIDITY**
- **VENTILATION**
- **AIR CHANGES**
- **PRESSURI-
ZATION**
- **FILTRATION**
- **BUILDING
OPERATING
SCHEDULE**
- **FLEXIBILITY**
- **COOLING LOAD**
- **NOISE**
- **HVAC CONCEPT**
- **FUME HOOD
EXHAUST**
- **MANIFOLDING**
- **ACCESS TO
MECHANICAL
EQUIPMENT**

PARTIAL INTERSTITIAL DISTRIBUTION





Adaptable Lab Casework

- User friendly (ADA)
- Moveable and adjustable furnishings
- Plug-in services: overhead or underfloor
- Generic M/E/P infrastructure

Current Flex Tables



Smart tables & utility trenches





FUME HOOD TYPES

- **CONVENTIONAL** (uncontrolled high face velocity, outmoded.)
- **BY-PASS** (constant volume)
- **MAKE-UP AIR** (aka auxiliary air, severe limitations on use)
- **VARIABLE AIR VOLUME**
- **LOW FACE VELOCITY**
- **PERCHLORIC** (danger)
Provide Fume Hood ALARMS!



Minimal Hood



Point Exhausts

- **Snorkels**
- **Balance Enclosures**
- **Slots, etc.**



Fume Hoods Contain:

- **Chemical vapors**
- **Smoke**
- **Heat**
- **Smells**
- **Aerosols**
- **Liquids**
- **Flying debris**
- **Flash**

But Can't Contain:

Explosions Dust
Biological agents
Storage of Chemicals



Room Exhaust Design Criteria

- **Total fume hood exhaust capacity**
- **Total local exhaust requirements**
- **“Air change rate”/ minimum ventilation rate for occupants**
- **Heat dissipation requirements**

Fume Hood Criteria

- **Total fume hood exhaust capacity)**
 - **total open sash area**
 - **100% outside air or partial return air**
 - **face velocity**
 - **OSHA: 60-100 fpm (feet per minute)**
 - **ANSI: 80-120 fpm**
 - **CAL OSHA: 150 fpm <12 cancer causing chemicals, 100 fpm otherwise**

Room Exhaust Criteria

- **“Minimum Air Change Rate”**
 - OSHA recommendation: 4-12 ACH
 - ASHRAE recommendation: 6-10 ACH
 - NFPA # 45 recommendation 4-8 ACH
- **Heat dissipation requirements**
 - With high heat loads, cutting back on fume hood exhaust may not save!



Laboratory Ventilation Options

- **Non- conditioned, “open window” scenario (Not recommended)**
- **Recirculating system**
- **100 % fresh air system**
 - **Constant Volume, uncontrolled**
 - **Two position VAV**
 - **Full VAV**

Energy Saving Options

- **Minimize total hood exhaust capacity**
 - **Introduce sash opening limitations but must be signed off on by users**
 - **Reduce face velocity below 100fpm (Not allowed in California under CAL OSHA)**
 - **Use smaller fume hoods or fewer**
 - **Use snorkels in some locations**
 - **Use ventilated work stations**
 - **Use ductless fume hoods, ?!?**

STACKS ON THE ROOF

**>5% of Fume Hood Stacks
Fail Due to meet ASHRAE
Guidelines Due to Wind**

**NORTH BAY
Chemical Spill Closes Napa
Outpatient Clinic**

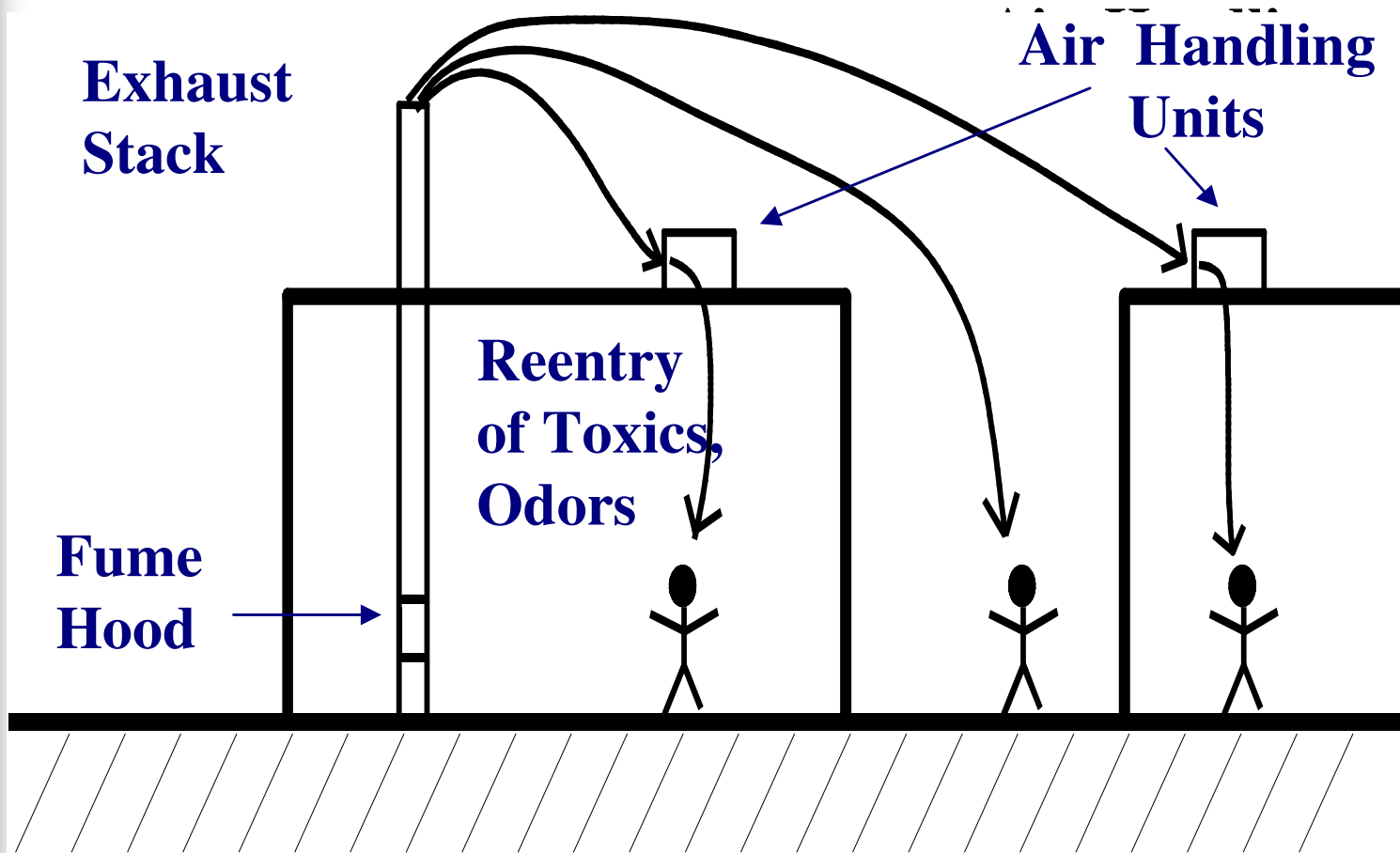
Tuesday, May 20, 1997

San Francisco Chronicle
CHRONICLE SECTIONS

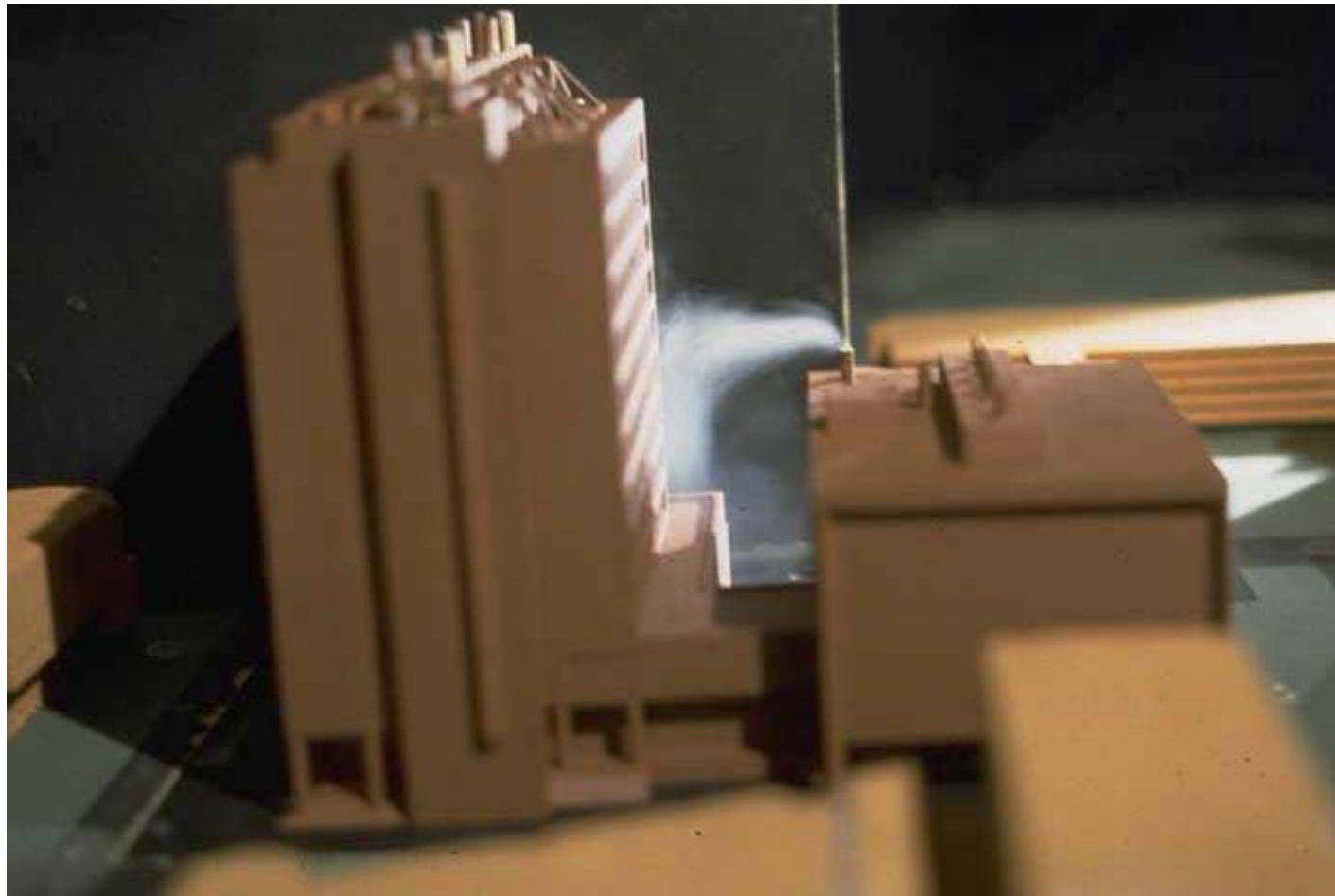
Spill of 16 ounces of phenol!

Graphics courtesy of CPP Wind Consultants

Re-entry of Exhaust Fumes



New Tall Lab Near Shorter Lab



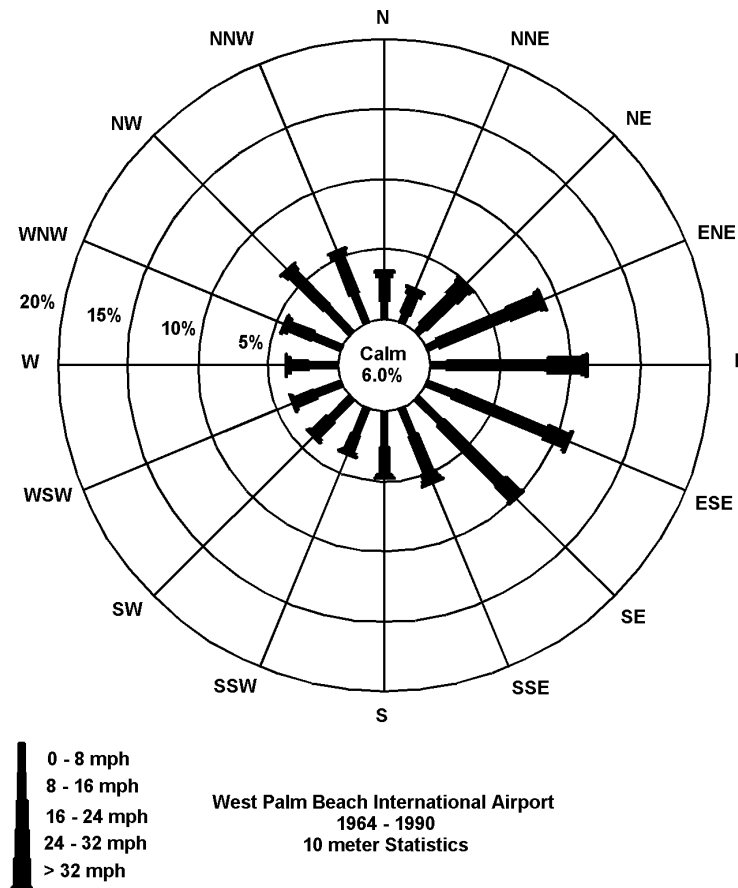
Stanford Pre-Renovation



Stanford Renovation



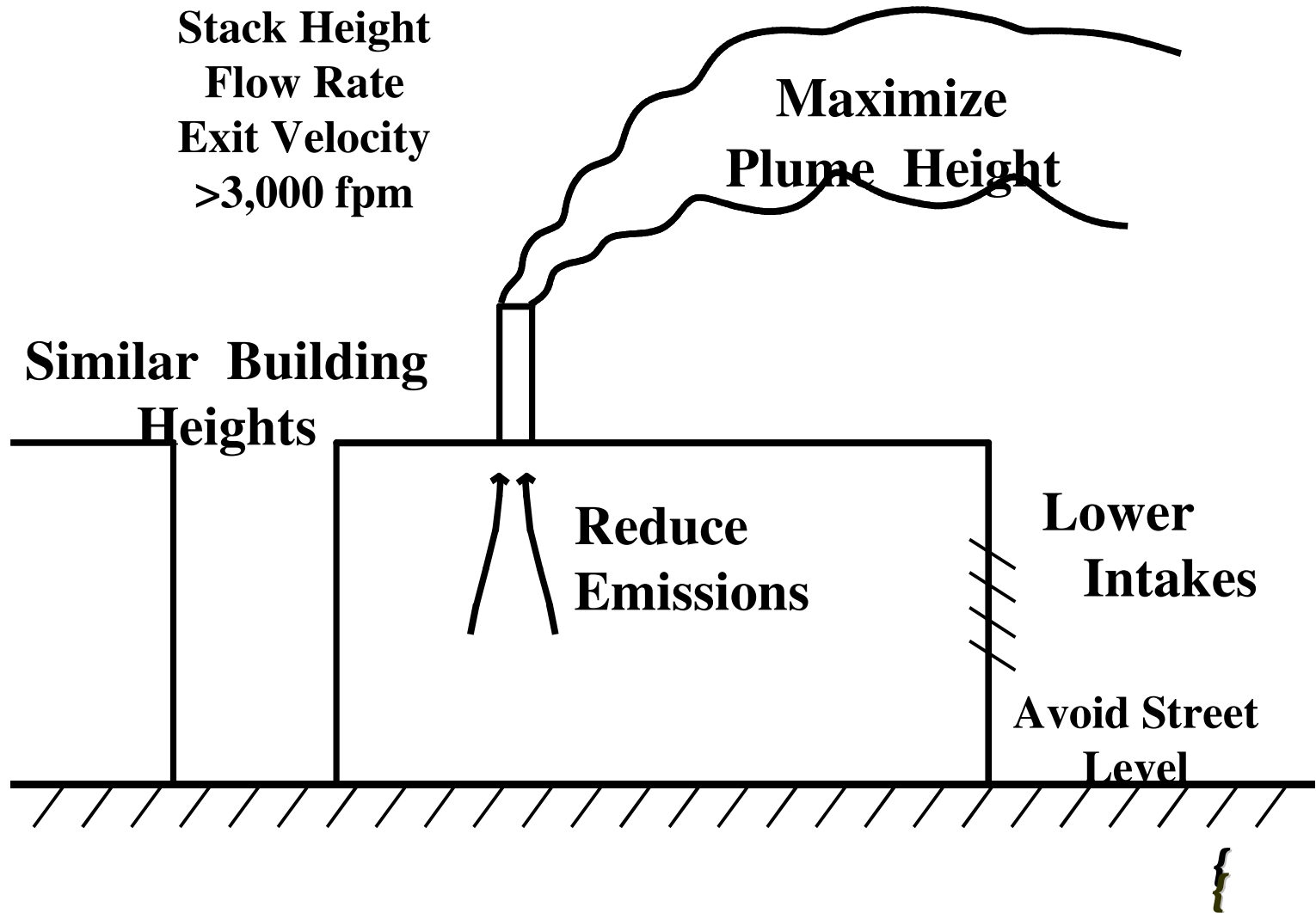
Wind Rose- No Prevailing Wind Directions



Stack/Intake Design Strategies

- *Reduce amount of chemicals*
- *Make airflow greater at fan exit, upward*
- *Avoid 1000-5000 cfm flows*
- *Taller, higher stacks w/ intakes further away*
- *Stacks 10' tall above roof (7' per Calif. Law) for maintenance worker protection*

Basic Design Parameters



Wind Tunnel Model





Rooftop Fume Exhaust Fans Deserve More Careful Design- Aesthetically & For Safety

- **One Stack Per Fume Hood** in most cases doesn't meet current ASHRAE Safety guidelines
- **One Stack Per Fume Hood is Unaesthetic- lots of clutter**
- **Address Safety Issue Early:
Bring in wind tunnel consultant.**



Claims, Errors & Omissions

- **\$10 million awarded to widow of laboratory worker in Texas in 1990**
- **Architect pays for wind tunnel study and to replace new 5,000 cfm exhaust fans at major research university in Santa Barbara**



What is a “Green” Laboratory

Courtesy of Jerry Koenigsberg



Definition

- **Embraces Principals of Sustainability**
- **Highly Energy Efficient**
- **Minimal Impact on the Environment**
- **Modified Laboratory Operations**
- **Accountable to Society**



Sustainability

**“Meeting the Needs of the Present
Without Compromising the Ability of
Future Generations to Meet their
Needs”**

Brundtland Commission 1987



Sustainable Concerns

- **Energy Consumption**
- **Resource Depletion**
- **Emissions**
- **Environmental Quality**
- **Indoor Air Quality**
- **Human Comfort/Performance**
- **First Cost/Operating Cost**
- **Life Cycle Assessment**



Sustainable Activities

● **Material Selection**

- **Recycling**
- **Reuse**
- **Selecting Local Products to Reduce Transport**
- **Tracking Materials Full Cycle from Raw Material and Fabrication Through Use and Eventual Recovery**
- **Dealing with Run-Off and On-Site Biological Treatment**



Reusable Building and Equipment Components

- **Demountable Partitions**
- **Recyclable Leased Carpeting**
- **Unitized Laboratory Casework**
 - **Modular Casework System**
 - Interchangeable System
 - Individual Cabinets
 - Independent Epoxy Resin Counter Tops



Minimize Impact On Environment

- **Be in Harmony with Surrounding**
- **Minimize Site/Civil Work**
- **Alternative Transportation to Site**
 - Public Transportation
 - Car Pooling
 - Other Vehicles
 - Bicycles
- **Use Exhaust Scrubbers**
- **Avoid Accidental Spills Entering The Waste Stream**



Operational Modifications

- **Minimize Waste & Emissions**
 - Incorporate “Micro Techniques”
 - Cap All Floor Drains
 - Seal All Floor Penetrations
- **Minimize Employee Exposure**
Reduce Usage of Toxic Materials
- **Direct Material Purchases with Green**
- **Chemical Substitution**
- **Institute Waste Recycling Treat Waste Stream on-Site**



Energy Efficient M.E.P. Design

- **Incorporate Natural Light into Design**
- **Appropriate Building Orientation**
- **Material Selection for Thermal Load**
- **Congeneration**
- **Hot Water Generation Options**
- **Heat Recovery**
- **“Energy Efficient” Lab Equipment**
 - **HOPEC Fume Hood**
 - **Local Exhaust Components**
 - **Local Equipment Chiller**



Accountability

- **Produce an Environmental Impact Study Prior to Executing a Project Design**
- **Set Specific Goals for Both Short and Long Term Efforts and Publicize Them**
- **Audit all Emissions Both Air and Liquid**
- **Produce an Annual Green Report**
- **Invite Community Representatives for All Green Activities**



US EPA Laboratory

Case Study I

US Environmental Protection Agency

Central R&D Laboratory Facility,

Research Triangle Park, NC, USA



US EPA Laboratory

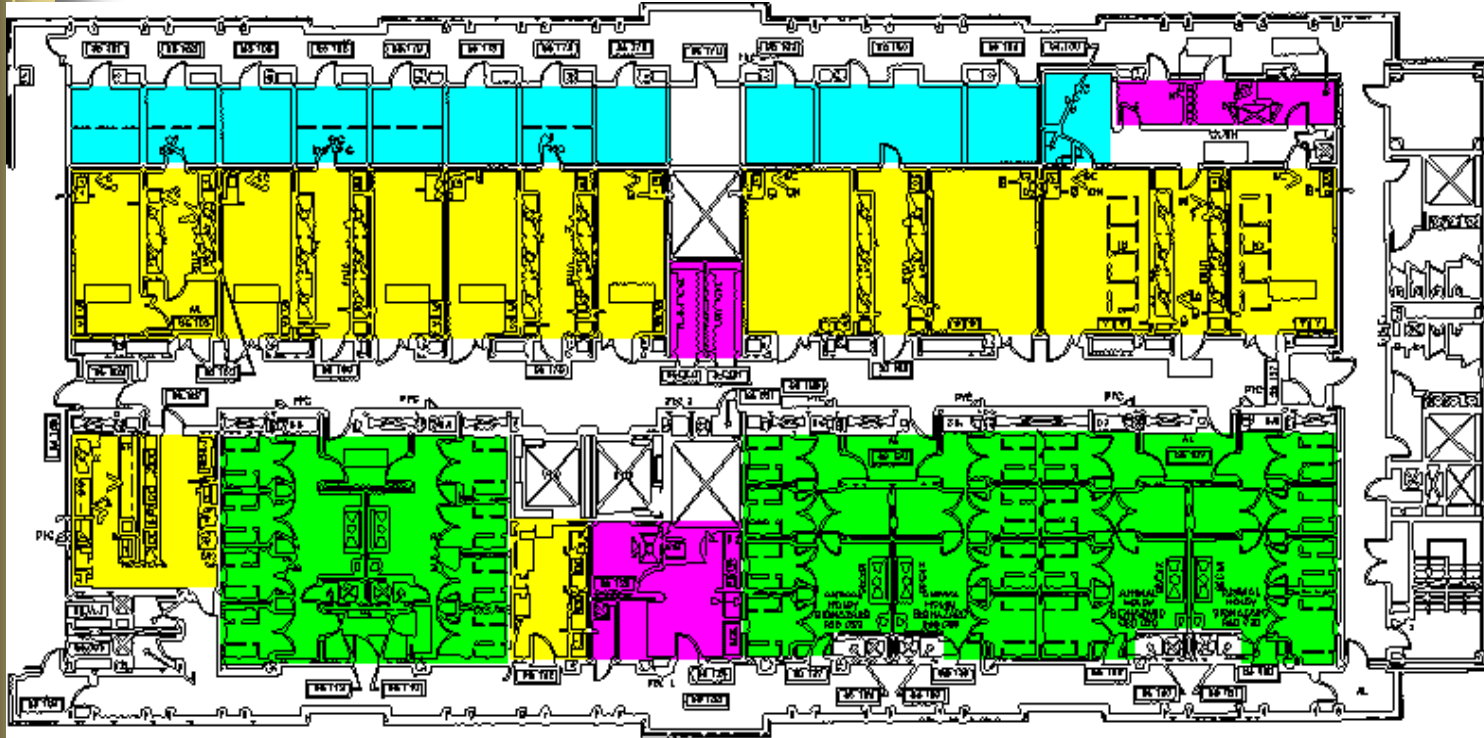
Project Statistics

- **Size: 100,000 Gross Square Meters**
- **Completion Date: January, 2001**
- **Cost: \$500 Million**
- **Occupancy: 2000 People**
- **Function: R&D, Analytical, Animal
Toxicology, Engine Testing**

US EPA Laboratory



US EPA Laboratory





US EPA Laboratory

Green Architecture

- **Building Oriented East/West Axis**
- **Site Work Requirements Minimized**
- **Minimal Roadways**
- **Interior Light Trays for Daylighting**
- **Secondary Light to Labs to Avoid Thermal Load**
- **Extensive Use of Atriums**
- **Triple Service Corridor Lab Configuration**
- **A Modular Building Design**



US EPA Laboratory

Green Engineering Techniques

- **Use the Highest Efficiency Mechanical Equipment and Motors**
- **Use Manifold Exhaust Design**
- **Apply Heat Recovery to Exhaust System**
- **Treat Storm Water Run-Off On-Site**
- **Use Energy Efficient HOPEC Fume Hoods**



US EPA Laboratory

Green Construction Techniques

- **Use Recycled Steel Components**
- **Limit Distance of Material Transport to 500 Kilometers**
- **Limit Use of VOC's**
- **Locate Concrete Plant to Site**
- **Grind Excavated Rock into Gravel**
- **Recycle Bituminous Material for Re-Manufacturing**
- **Limit Material Packaging**
- **Return Unused Material to Vendors for Credit**



US EPA Laboratory

Green Equipment/Supply Selection

- **Unitized Casework System**
- **Individual Epoxy Resin Counter Tops**
- **Demountable Partitions**
- **Epoxy Coated Service Fittings**
- **Universally Sized HOPEC Fume Hoods**
- **Modify Packaging of Supplies**
- **Recycle Solvents**

Sustainable Fume Hood “HOPEC”



what if?



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